Upper Extremity Overuse Injuries and Obesity After Spinal Cord Injury

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Persons with spinal cord injury (SCI) are at high risk for developing neurogenic obesity due to muscle paralysis and obligatory sarcopenia, sympathetic blunting, anabolic deficiency, and blunted satiety. Persons with SCI are also at high risk for shoulder, elbow, wrist, and hand injuries, including neuromusculoskeletal pathologies and nociceptive pain, as human upper extremities are poorly designed to facilitate chronic weight-bearing activities, including manual wheelchair propulsion, transfers, self-care, and day-to-day activities. This article reviews current literature on the relationship between obesity and increased body weight with upper extremity overuse injuries, detailing pathology at the shoulders, elbows, and wrists that elicit pain and functional decline and stressing the importance of weight management to preserve function. **Key words**: *elbow pain, obesity, overuse, shoulder pain, spinal cord injury, upper extremity, wrist pain*

Introduction

The spinal cord is the major nervous conduit through which motor, sensory, and autonomic system information travels between the brain and body.[1,2] A spinal cord injury (SCI) can affect conduction of these signals, resulting in neurologic deficits below the level of injury that can be temporary or permanent. The term “tetraplegia” is used for impairment, or loss of motor or sensory function in both the upper and lower extremities, caused by an injury in the cervical segments of the spinal cord, and “paraplegia” is used for impairment, or loss of motor or sensory function in the lower parts of the body, caused by an injury in the thoracic, lumbar, or sacral segments of the spinal cord.[1-3]

Obesity can be defined as progressive abnormal or unnecessary fat accumulation that may be detrimental for health.[4] The underlying cause is an energy imbalance between calories consumed and calories expended.[4,5] It is a major health issue in the United States in both able-bodied and disabled populations, and its prevalence continues to increase.[6] The prevalence of obesity has been described to be over 75% in persons with SCI.[7,8] This high prevalence in the SCI population can at least partly be attributed to the significant increase in body weight of approximately 15 pounds during the acute period of SCI.[9] Persons with SCI are at high risk for developing neurogenic obesity due to muscle paralysis and obligatory sarcopenia, sympathetic blunting, anabolic deficiency, and blunted satiety.[4,10] Measuring and defining obesity for the SCI population has been challenging and controversial.[11] The World Health Organization (WHO) obesity classification based on body mass index (BMI) should be considered as only a rough guide because it may not correspond to the same degree of fat mass in persons with SCI as in the population on which it was based.[4,11] The traditional BMI cutoff of 30 kg/m^2 fails to identify the high percentage of persons with SCI who are truly obese.[11,12] Persons with SCI commonly have more body fat than nondisabled controls.[11,13] Because of these limitations, the use of an adjusted BMI classification for persons with SCI with lower BMI ranges is recommended (i.e., ≥ 22 kg/m^2).[7,11,12,14,15]

For the person with an SCI, the upper extremities are of great importance for mobility, transfers, self-care, and day-to-day activities.[16,17] If the person is also overweight or obese, these tasks can be more challenging and have additional adverse effects in the upper extremities due to overuse injuries.[17] Awareness of the relationship between obesity and

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upper limb overuse injuries should be emphasized as the life expectancy for persons with SCI continues to increase.[18] Upper limb utilization for weight-bearing activities over many years challenges joints that are not designed primarily for that purpose.[19] Musculoskeletal pain in the upper extremities of persons with SCI can be an incapacitating condition and have great impact on their quality of life.[17,20] The goal of this article is to provide an overview of the common upper extremity overuse injuries that can be present in persons with SCI and how increased weight can affect these pathologies, resulting in pain-limiting mobility and activities of daily living. The mobility and functional impacts of obesity in SCI are reviewed as well.

Upper Extremity Overuse Injuries

Persons with an SCI understandably depend more on their upper extremities than nondisabled persons for daily activities such as mobility, ambulation, transfers, and self-care.[16,17,19] Musculoskeletal pain secondary to overuse injury in the upper extremity is among the most prevalent pain complaints in persons with SCI.[21-23] It has been described that significant upper extremity pain can be present in 80% of persons with tetraplegia[21] and 81% of those with paraplegia.[22] These complications can be detrimental to functional independence in persons with SCI; 26% of individuals experiencing upper limb pain need additional help with functional activities, and 28% report limitations of independence.[24]

Because of lower extremity weakness or paralysis after an SCI, the upper extremities are used more frequently for daily living activities and to aid mobility. It is expected that the prevalence of upper extremity problems would be higher in this population and that increased body weight would exacerbate these musculoskeletal and neurologic complications secondary to overuse. Some risk factors found in this population are higher BMI and the use of a manual wheelchair.[25] A higher body weight will lead to an increase in load on the upper extremities during wheelchair propulsion or when performing a transfer, which can lead to problems due to musculoskeletal overuse of the upper extremities, which is common in persons with SCI and can lead to a further decrease in activity.[26,27]

Shoulder Dysfunction

The shoulder is the most common source of musculoskeletal pain in persons with SCI,[24] with >78% of persons with SCI reporting shoulder pain.[21,22,28] Many studies attribute this high prevalence to overuse injuries, with common diagnoses including impingement syndrome, capsulitis, osteoarthritis, dislocations, rotator cuff tears, and bicipital tendinitis.[23,29,30] It has been described that shoulder pain is more common in persons with tetraplegia (53%) than paraplegia (16%) within 5 years post injury. In the chronic phase, by 20 years post injury, a higher percent of individuals with paraplegia had shoulder pain compared to those with tetraplegia, although recent literature suggests prevalence is approximately the same.[21-23] Of note, one study reported experience of shoulder pain post injury in 35% of persons with paraplegia and in 100% of persons who were more than 25 years post injury.[31] This increased prevalence of shoulder pain among manual wheelchair users over time likely represents repetitive strain injuries from increasing body weight over many years of transfers and manual wheelchair use.[24,28,32]

Several studies have examined the pathophysiology of shoulder pain and injury in persons with SCI. An early study found that during a wheelchair transfer, intraarticular pressures in the shoulder can increase more than two times arterial pressure, potentially affecting the vasculature of the rotator cuff tendon and predisposing it to injury.[29] Repeated performance of activities that place a high load on the shoulders, such as wheelchair propulsion or transfers, can alter shoulder tendon microstructure and lead to tendon injury or pathology.[33-35] The chronic overload on the shoulder joint due to the use of the upper limb as a supporting joint is worsened for persons with excess body weight. Narrowing of the joint space in the shoulder, another common anatomical abnormality among active wheelchair users, may also lead to impingement and injury of the rotator cuff.[36] Chronic forceful activities in manual wheelchair users such as transfers and propulsion can cause muscle imbalances that can eventually lead to shoulder joint dysfunction.[37] A study comparing the number of magnetic resonance imaging (MRI) abnormalities in the shoulder and an individual's weight found a positive relationship between more image abnormalities and increased weight.[38] This relationship was thought to be due to the excess work and strain required to perform transfers and wheelchair propulsion for persons with increased body weight. A multicenter study found that increased BMI becomes a significant risk factor for shoulder pain if the subject does more than 12 transfers per day. An overweight person increases the intraarticular pressure at the shoulder joint during transfers, increasing the likelihood of shoulder pain and pathology.[39]

Elbow Dysfunction

Prevalence of elbow pain in persons with SCI has been reported to be between 6% and 15%. Musculoskeletal problems at the elbow can be the result of strained muscles and tendons, nerve impingement, or both.[23,40] In one study of compressive mononeuropathies in chronic paraplegic persons, 67% of them had evidence of at least one compressive mononeuropathy according to electrodiagnostic criteria, including 10% of individuals with an ulnar neuropathy across the elbow.[41] This entrapment of the ulnar nerve at the elbow can occur at the cubital tunnel during full flexion of the elbow. It was suggested that compressive mononeuropathies of the ulnar nerve at the elbow may be a function of repetitive trauma while propelling a wheelchair, and presumably this risk would increase with a heavier limb; direct compression of the nerve while resting the forearms on the wheelchair arm rests was also suggested.[41] Another study found slower motor conduction velocity of the ulnar nerve across the elbow among paraplegic wheelchair users compared to a nondisabled control group.[42]

The propulsive stroke of everyday and athletic wheelchair users involves pronation of the forearm and extension of the elbow, coupled with extension of the wrist and gripping of the hand at the start of the propulsive stroke. This position of the elbow and hand may place a person with SCI at higher risk for lateral epicondylitis.[43] In addition, high forces are felt at the elbow during transfers, which can stress the soft tissues of the joint and potentially contribute to musculoskeletal injury.[44] Finally, a cross-sectional controlled study evaluating the elbow joint with ultrasound in persons with paraplegia compared to nondisabled controls demonstrated that mean triceps tendon thickness values were larger in those with SCI, with a positive correlation to BMI.[45]

Wrist Dysfunction

Like the shoulder and elbow joint, wrist pain can be caused by musculoskeletal and nerve overuse injuries. Carpal tunnel syndrome (CTS) has been described as the most common cause of wrist pain and hand pain in wheelchair users with paraplegia.[23,46-48] Prevalence of CTS in persons with SCI has been found to be higher than in age- and gender-matched nondisabled controls.[46] Despite similar BMI, 63% of 56 wheelchair users with paraplegia for more than 25 years had clinically proven CTS compared to only 7% of age- and gender-matched nondisabled controls, and 73% of those with SCI had electrodiagnosis of median mononeuropathy at the wrist compared to 34% of controls.[46] In a large study before the turn of the century, historical or physical examination evidence of CTS was found in 66% of persons with paraplegia; other causes of wrist and hand pain not associated with CTS were reported in 13% and 11%, respectively.[23] Another study in the 1980s found that 49% of persons with paraplegia had signs and symptoms of CTS[31]; both studies found that the incidence of CTS increased with a longer duration of paralysis. More recent studies have demonstrated that 60% and 64.6% of persons with chronic paraplegia had clinical symptoms of CTS, respectively; 78% and 71% had electrodiagnostic evidence of median mononeuropathy at the wrist, respectively.[47,48]

As with the shoulder and elbow, the higher prevalence of CTS in this population has been attributed to wheelchair use and frequent transfers. Risk factors for CTS in the SCI population include increased body weight and BMI, older age, longer duration of paralysis, and overuse of the wrist and hand during wheelchair activities, such as wheelchair propulsion.[43,48] Individuals with increased weight and BMI who propel with higher forces and more strokes have been shown to exhibit electrodiagnostic signs of CTS such as median nerve slowing and amplitude loss.[26] Prolonged use of the manual wheelchair is associated with more severe forms of CTS. A recent study found a relationship in age and time since injury among groups of different levels of CTS severity. Severe CTS was more related to prolonged wheelchair use than it was to old age.[47]

Wheelchair users with SCI are susceptible to peripheral neuropathies from overuse, yet few studies have evaluated median nerve imaging findings and wheelchair transfers. Ultrasound examination after repeated transfers revealed increased cross-sectional area (CSA) of the median nerve that could predispose to CTS. This changes were greater in subjects with higher body weight, who exhibit greater reaction forces at the wrist joint during transfers.[49]

SCI Obesity and Functional Mobility

Limited studies have examined the impact of body weight on rehabilitation outcomes or functional recovery. In general, studies report a negative association between obesity and rehabilitation outcomes.[50-52] An obese person with new SCI will likely encounter unique problems during their rehabilitation and postdischarge process that could be directly or indirectly attributed to their excess weight. Obesity will likely interfere with an individual's ultimate functional outcome for mobility and self-care goals. Persons with SCI typically have functional decline over time, and those who are obese are more likely to experience decreases in physical independence and community integration than those in the normal weight category.[50,51] Body weight influences a person's ability to propel a wheelchair, and those with higher BMI cannot push as far as those with lower BMIs. In a study evaluating wheelchair propulsion, persons with obesity pushed 19% less than those who were not obese, or 0.30 mile less per day.[14] Of note, BMI was shown to increase over 5 years in veterans with newly acquired SCI,[9] despite the fact that muscle and bone mass decreased such that weight changes reflected gain of adipose tissue.[13]

A study using the National SCI Statistical Center (NSCISC) data from the National Institute of Disability, Independent Living and Rehabilitation Research (NIDILRR) SCI Model Systems programs reported that obesity was a significant predictor of motor FIM scores among persons with paraplegia but not those with tetraplegia.[53] This retrospective study of 1524 inpatients with new traumatic SCI reported that persons with complete paraplegia and obesity had significantly lower FIM mobility and self-care score gains than those with complete paraplegia and normal weight.[53] This finding was not consistent with patients with tetraplegia likely due to ceiling effects of the FIM metrics and limited gains regardless of body weight. Similarly, significant associations between BMI and FIM scores in another multisite trial were only seen in persons with paraplegia American Spinal Injury Association Impairment Scale (AIS) grades A, B, and C group.[52] Those with tetraplegia had limited gains due to limited neurological capacity. On inpatient discharge, obese and overweight patients achieved lower motor FIM scores than those with a healthy weight by 3.1 points and 1.2 points, respectively.[52] It is plausible that manual wheelchairs are often the primary means of locomotion among those with paraplegia AIS grade A, B, and C scores, with the expectation of self-transfers and self-propulsion. Some weight-dependent functional activities are therefore more challenging among this group compared with the AIS D group who are more ambulatory and those with tetraplegia who would more likely use a power wheelchair and have a caregiver for transfers and activities of daily living.[52,53]

Conclusion

Obesity and increased weight significantly contribute to upper extremity overuse injuries at the shoulders, elbows, and wrists of persons with SCI, resulting in pain-limiting mobility and activities of daily living.[54] Weight management is essential to minimize upper extremity overuse, in addition to wheelchair kinematics, transfers, weight shifts, and appropriate, balanced resistance training for upper extremity strength and conditioning.[17,20,52] Although it would appear robust, the literature demonstrating the relationship between obesity or body weight with upper extremity overuse is limited. Prospective, randomized controlled trials to demonstrate weight loss or maintenance of healthy weight influence on upper extremity function and pathology are required to optimize clinical recommendations and guidelines. A recent call for updated clinical practice guidelines to preserve upper extremities in manual wheelchair users discussed wheelchair propulsion, skill acquisition, wheelchair equipment and maintenance, resistance training, pain identification and environment but failed to acknowledge the importance of body weight on injury prevention and overuse.[55] As in the general population, the mainstay of a weight loss program is diet. However, solely targeting the patient's diet may not be effective enough because the resting metabolic rate is estimated to be 14% to 54% lower in persons with SCI compared to the general population due to reduced fat-free mass and sympathetic blunting.[56,57] Although there is no established intervention to reduce obesity after SCI, active research is focused on programs addressing increased physical activity, exercise, diet, and education.[10,13,57]

Conflicts of Interest

The authors report no conflicts of interest.

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